October 29, 2002

MEMORANDUM TO: Loren R. Plisco, Director
Division of Reactor Projects
Region II

FROM: Ledyard B. Marsh, Deputy Director ***/RA/***
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: RESPONSE TO TASK INTERFACE AGREEMENT 2002-05 REGARDING REVIEW OF OCONEE STEAM GENERATOR TUBE STRESSES RESULTING FROM USE OF THE STATION ASW PUMP (TAC NOS. MB6252, MB6253, AND MB6254)

In a memorandum dated September 10, 2002, you requested assistance from the Office of Nuclear Reactor Regulation in reviewing a structural analysis performed for Oconee Nuclear Station, Units 1, 2, and 3. The structural analysis was performed because steam generator tube-to-shell differential temperatures substantially exceeded the vendor's limits as a result of delays in placing the station's auxiliary pump in service in the licensee's tornado mitigation strategy.

We have completed our review of the licensee's structural analysis. We conclude that the methodology employed by the licensee is appropriate, and the analysis is fundamentally sound. Our Safety Evaluation is attached.

This completes our action under TAC Nos. MB6252, MB6253, and MB6254.

Docket Nos. 50-269, 50-270, and 50-287

Attachment: As stated

cc w/att: B. Platchek, R-I
G. Grant, R-III
K. Brockman, R-IV

CONTACT: Leonard N. Olshan
301-415-1419

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING TASK INTERFACE AGREEMENT 2002-05

OCONEE STEAM GENERATOR STRESSES RESULTING

FROM USE OF THE STATION ASW PUMP

DUKE ENERGY CORPORATION

OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-269, 50-270, AND 50-287

## 1.0 BACKGROUND

In a memorandum dated September 10, 2002, Region II initiated Task Interface Agreement (TIA) 2002-05. The TIA requested that the Office of Nuclear Reactor Regulation (NRR) review a structural analysis that was performed by Duke Energy Corporation (the licensee) to resolve an Unresolved Item.

During a problem identification and resolution inspection, Unresolved Item (URI) 50-269,270,287/2001-08-02, "Steam Generator Tube Stresses Resulting From Use of the Station ASW Pump," was identified for Oconee Nuclear Station, Units 1, 2, and 3. This URI involved steam generator (SG) tube-to-shell differential temperatures that substantially exceeded the vendor's limit. These differential temperatures occurred as a result of revisions to the licensee's mitigation strategy for certain tornado events as a result of delays in placing the station auxiliary service water (ASW) pump in service. While this condition was recognized, the impact of these increased differential temperatures on tube stresses had not been evaluated by the licensee.

The licensee has completed its analysis and made it available to the staff in a document entitled, "Oconee Nuclear Station, Units 1, 2, and 3 Calculation No. OSC-8055, ONS Tornado Event Transients-OTSG Tube Allowable Flaw Size and Tube Integrity Under Axial Compression with Either Axial or Circumferential Tube Degradation," (OSC-8055) with two attachments to the document.

## 2.0 EVALUATION

The review of the analysis and testing of Oconee SG tube stresses resulting from use of the station ASW pump is focused on the two attachments to OSC-8055. OSC-8055 provided a summary report. The first attachment to OSC-8055 presented the Framatome (FANP) calculation addressing "axially oriented" SG tube flaws, and the second attachment presented the Foreline Associates report addressing "circumferentially oriented" SG tube flaws through laboratory testing and confirms the axial flaw finite element analysis performed by FANP. The

review was based on requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, 1989 Edition without Addendum, and NEI 97-06, “Steam Generator Program Guidelines,” published by the Nuclear Energy Institute in December 1997. Other references, as listed in Section 8.0, "References," of the first attachment were used in the review where applicable.

The design method, analytical method, and associated assumptions summarized in calculation OSC-8055, Rev. 0, appear to be reasonable and conservative. Details of the analysis and complete justification of statements made in Section 5, “Conclusion,” are provided in two attachments. Comments and follow up questions resulting from the review of these attachments, requiring clarification or improvement, are summarized as follows:

A. FANP Calculation 32-5015496-02

1. Reference 6, "ANSYS" Finite Element Computer Code, Version 5.6, was used for the tube stress analysis. An internal computer code bench marking file should have been created and referenced to demonstrate that the use of Elements (such as SOLID45) and post processors were appropriate for this application.

2. Section 2.2.1 stated that "in order to more realistically model the tube bundle, the norminal actual thickness of the tube wall is used (0.037") as opposed to the minimum wall (0.034") . . .". This approach is normally acceptable. However, in view of the analysis results on pages 65 and 66, it is not obvious that the above approach can be justified without further explanation. The safety factors (3.00 and 1.43) may fall below the required values if the minimum wall thickness of the tube is used in the analysis and the subsequent calculation. (Please refer to comment 6 below for more details.)

3. Section 2.2.3 discussed the loads. The thermal loading is applied to the SG model via a "fluid temperature" and corresponding "heat transfer (film) coefficient". Fluid temperatures were described in later sections. However, the calculation of film coefficients and the modes of heat transfer considered in the calculation were not explained other than introducing a Reference 5. Since heat transfer is the primary loading for the case being evaluated, additional information should be inserted into the document.

4. Did FANP independently verify the element of ANSYS that performs the buckling response analysis? Also should the responses in Section 3.3 be reviewed starting at around 0.485 hour in the simulation to verify that motions are reasonable considering the plastic hinge effect?

5. The last paragraph of Section 5.2 stated that "The reason that the flaw was specified to be on the surface may have been because the majority of axial flaws found during actual in-service inspections are located on the OD." This justification should be strengthened.

6. The calculated safety factors in Sections 5.5.4 and 5.5.5 were exactly the same values as required by NEI 97-06 using the norminal average tube wall thickness (see comment 2 above). If the minimum tube wall thickness were used in the analysis and calculation, it may be difficult to demonstrate the required safety factors for the loading conditions unless some intended conservatism are identified and removed.

The licensee should provide additional information regarding to the acceptability of the results and the conclusions.

B. ForeLine Calculation FA-DUKE-016, Rev. 2

The series of axial compression tests simulating expected loading of SG tubing under a postulated Oconee tornado event transient were performed. The objective of these tests was to determine the structural integrity limits of tubing containing narrow circumferential notches to simulate circumferential cracks. The tests generated sufficient crack tolerance data to justify either a zero increase in crack length or a zero leakage criteria under specified conditions.

A series of burst tests of tubing containing axial partial through wall notches with and without axial compression loading were also performed to confirm strength of materials expectations and finite element calculations presented in the first attachment to OSC-8055 and commented by the staff in A above.

The tests were successful in demonstrating the intended purpose and provided confirmation on:

1. Tubing structural integrity under simulated circumferential flaws, and
2. Basic assumptions and conclusions arrived through finite element analyses.

3.0 CONCLUSION

A review of a "for information only" copy of OSC-8055 and its two attachments was performed by the NRR staff in evaluating the Oconee SG tube stresses and structural integrity resulting from the use of station ASW pump under a postulated tornado event transient. The staff concludes that the methodology employed by the licensee is appropriate, and the analysis performed is fundamentally sound. The evaluation included the generation of tube axial compression loading due to end motion, finite element analysis using the ANSYS computer code for axially oriented SG tube flaws, and laboratory testing for circumferentially oriented SG tube flaws. Evaluations were primarily based on elastic system/plastic component analysis using criteria F-1340 of ASME Code, Section III and NEI 97-06. The above comments are suggested improvements and are not anticipated to impact any conclusions arrived in the reports. Since several extremely conservative assumptions were included in the analysis and testing, the conclusions of the licensee's analysis appear to be appropriate and defendable.

Principal Contributor: K. Chang

Dated: October 29, 2002

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